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Memorandum:
Effect of Taper Angle Variation on the Submillimeter Far-Infrared Transmission Efficiency of Linearly Tapered Light Pipes

by

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REPORT

by

THE OHIO STATE UNIVERSITY RESEARCH FOUNDATION
COLUMBUS, OHIO 43212

Sponsor	National Aeronautics and Space Administration 1520 H. Street Northwest Washington 25, D.C.
Grant Number	NsG-74-60
Investigation of	Receiver Techniques and Detectors for Use at Millimeter and Submillimeter Wave Lengths
Subject of Report	A Technical Memorandum on the Effect of Taper Angle Variation on the Submillimeter, Far-Infrared Transmission Efficiency of Linearly Tapered Light Pipes
Submitted by	Glenn G. Shephard Antenna Laboratory Department of Electrical Engineering
Date	26 May 1964

A TECHNICAL MEMORANDUM ON THE EFFECT OF TAPER ANGLE VARIATION ON THE SUBMILLIMETER, FAR-INFRARED TRANSMISSION EFFICIENCY OF LINEARLY TAPERED LIGHT PIPES

i 7864

Speculation regarding the effect of taper angle variation on the transmission efficiency, in the submillimeter far-infrared, of tapered light pipes prompted the following experiment. Its purpose was to determine empirically the magnitude of transmission change with taper angle, thus establishing the significance of this factor in light pipe design. The procedures used and the data taken are admittedly crude but it is believed to be concrete enough to relegate light pipe taper angle variation effects to the domain of the second or higher order.

Author

The apparatus for the experiment consisted of the following:

(1) A stainless steel tube 23 inches long and 11/16 inch in diameter, polished along the entire inner surface.

(2) Six linearly tapered brass sections (having "slip fits" in the stainless steel tube), all with large diameters of 11/16 inch and small exit diameters of 5/32 inch, numbered according to length, and polished throughout.

Number	Length (inches)
1	3
2*	$3\frac{1}{2}$
3	4
4*	$4\frac{1}{2}$
5	5
6	6

(3) An Eppley Labs. Golay detector.[1]

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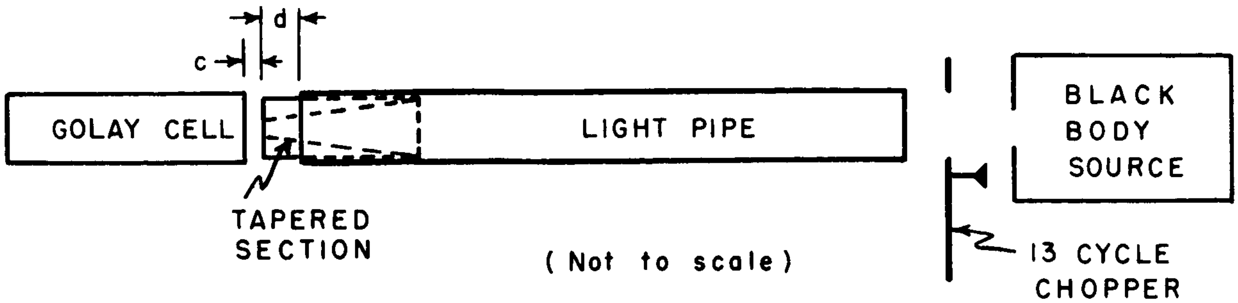
*These sections were made by a different machinist.

[1] Black polyethylene and crystal quartz were used as filters on the Golay cell.

(4) A Barnes Engineering blackbody source.

The equipment arrangement was as shown below. The basic idea in



making measurements was to record the differences in relative transmission through the light pipe-taper combination for the six different tapers, while maintaining a constant overall length. To this end the distances c($\simeq$1/16 in.) and d($\simeq$1/2 in.) were held constant for all measurements.[2] Throughout the experiment the blackbody was set at 50°C. The transmission data taken was recorded on an arbitrary scale running from zero to ten and will be given unitless.

With no taper present and the Golay cell at c + d from the end of the pipe, the relative transmission was 4.9. Four runs were made with the tapers: ascending, descending, ascending and descending in order. The data obtained are presented below.

Taper Number	Angle (deg)	Relative Transmission Runs 1	2	3	4	Avg
1	2.5	7.9	7.7	7.7	7.9	7.8
2	3.0	6.3	6.5	6.6	7.2	6.6
3	3.4	7.5	7.7	7.2	8.0	7.6
4	3.8	7.3	7.0	7.3	7.4	7.2
5	4.3	7.3	7.1	7.8	7.5	7.4
6	5.1	7.6	7.7	7.8	8.2	7.8

[2] The estimated deviation in d was $\pm$1/64 inch.

From these data there are several observations and points to be made and noted. The inconsistency in the data from run to run points in two directions. First is the alignment and realignment problem, which was a consequence of taper exchange. This undoubtedly introduced a randomly distributed error. Secondly, because of the time required to maximize transmission (a result of alignment difficulties) the drift of the Golay detector must be considered as a contributing error source. To be noted in addition is the consistently low (relative to tapers 1, 3, 5, and 6) transmission of tapers 2 and 3.

The conclusions which have been drawn from these results are as follows:

(1) A tapered light pipe is definitely more efficient in the submillimeter than a non-tapered pipe, as indicated by the non-tapered transmission of 4.9 and the tapered average transmission of 7.4.[3]

(2) The angle of taper on a tapered light pipe for the submillimeter is relatively unimportant for most present-day applications, especially when it is noted that non-observable differences in fabrication create greater transmission changes.

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[3] Direct comparison of transmissions 4.9 and 7.4 is not possible because of gap of c+d between Golay cell and the empty end of the light pipe.